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METEOROLOGICAL OPTICS.

Meteorologische Optik. By Prof. J. M. Pernter. In three parts. Pp. 558. (Vienna and Leipzig: W. Braumüller, 1902–6.)

THE subject of "meteorological optics" has scarcely yet reached recognition as a distinct branch of physical science, as one of which it were desirable that the phenomena should be systematically gathered together in order that the interaction of all the circumstances affecting any one group of appearances might be the more clearly appreciated. The various matters which may be legitimately included under such a title have, individually, not failed of their full share of attention and discussion—in the nature of the case they have from the earliest times been the subject of curious, though not always careful, observation and speculation, and of most of the phenomena an explanation, at any rate approximate, has already been satisfactorily given. The cause of the blue of the sky and of the "twinkling" of the stars, the theory of mirage, of the rainbow, of halos and mock suns, of all these much has been written, and by many physicists of eminence, but an exhaustive classification of all the questions which fall within the domain of meteorological optics has perhaps hardly been attempted.

From the optical side, the most complete account of the subject previously given is to be found in Mascart's "Traité d'Optique"; but the accumulation of meteorological data has proceeded somewhat more rapidly of recent years, and it is to the meteorologist that we must look for the exact quantitative solution of many problems in which the optical theory has already been correctly indicated. Prof. Pernter has every qualification for the task which he has set himself, and as director of the Imperial Institution in Vienna for the study of meteorology and terrestrial magnetism he brings to his subject an acquaintance with meteorological data such as few can claim. His book will rank as a classic of scientific literature, and is little likely to be superseded, within more than one generation, as the standard work on this branch of natural science.

Prof. Pernter explains that his work is based on lectures delivered during a period of ten years in the Universities of Innsbruck and Vienna. It is, however, singularly free from the defects one is prepared to find in a volume so produced; it is neither too diffuse nor too exclusively technical, and while essentially scientific, in the strictest sense, in its aim of giving an exact numerical explanation of the phenomena recorded, it furnishes a descriptive account of the appearances dealt with, from the records of observations, old and new, which the least scientific reader can scarcely fail to find attractive.

To the contents of the four sections into which the subject is divided the author's own classification is the best guide. The first section deals with the apparent forms of the vault of the sky and the phenomena connected therewith—over-estimation of the heights of mountains, the apparent variation in size of sun, moon, and constellations between horizon and zenith, &c. In section ii. are included all the phenomena which owe their origin to the gaseous constituents of the atmosphere, whether under normal or abnormal conditions—astronomical refraction, depression of the horizon, mirage, the "Fata Morgana," and the scintillation of the stars. In the third section are considered the effects due to the presence in the atmosphere of masses of particles the appearance of which is intermittent—clouds, whether of ice crystals or rain-drops; and here we find a full discussion of halos and parhelia, coronæ and rainbows. The fourth section, which will be issued next autumn, will treat of the phenomena due to the existence in the atmosphere of very minute particles of whatever nature which are always present, but which are especially numerous at certain times, as after volcanic eruptions. The classification thus indicated is both natural and convenient; with but rare exceptions it brings together all those phenomena which are of similar origin, and therefore demand similar treatment.

Of the first section it will suffice to say that Prof. Pernter gives a very careful discussion of the apparent form of the "vault" of the sky, basing his numerical results especially on the observations of Reimann. His conclusion is that the form is that of a segment of a circle, the arc of which subtends at the centre an angle of the order of 40°. From this it follows that estimations of dimensions near the horizon and at higher altitudes will differ widely, a factor having important bearings, as already indicated, in regard to many every-day phenomena, to which we may add the apparently oval form of halos and coronæ at low altitudes. In his explanation, or rather his suggestion, as to the direction in which an explanation must be sought, the author follows Gauss, who first made experiments to show that this subjective effect is mainly due to the normally upright position of the body, and to the abnormal, or at least unusual, procedure involved in raising the eyes from the horizon to the zenith. It need hardly be added that there are many points here demanding further discussion.

The second section passes from the consideration of the effects due to atmospheric refraction under normal conditions to a very full and interesting account of the various phenomena due to reflection and refraction when the density of successive layers of the atmosphere shows abnormal variations or when the density in any region is subject to rapid fluctuations. Prof. Pernter is perhaps here at his best. For the descriptive portion of the work he has sought the most typical examples to be found in scientific literature, giving in the words of the actual observers the details the explanation of which he afterwards follows out as closely as possible from the most exact data obtainable relative to the variations of atmospheric density. We may direct attention especially to the author's theory of cases of exceptional "visibility" of distant objects, apparent nearness and magnification. His theory of the

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different forms of mirage, whether due to reflection from above or below, or from the side, is essentially that given by Tait in his paper "On Mirage" in the Edinburgh Transactions. Of the "Fata Morgana," two specially interesting examples are cited from observations by Prof. Boccara in 1900 and 1901, while of distortion due to abnormal atmospheric refraction the most striking cases are those seen by Arctowski, as quoted from the records of the Belgian Antarctic Expedition.

The theory of the scintillation of the stars and planets, and of the analogous phenomena observed in the sun and moon when almost eclipsed, has aroused an exceptional amount of attention, and is here very fully considered. Lord Rayleigh has discussed the matter in a paper on the theory of stellar scintillation, where the failure of the "interference" theory as propounded by Arago is made clear. The various optical effects in which the phenomenon may be said to consist, the quivering and the fluctuations in intensity and colour, as well as the meteorological conditions, the extent and character of the atmospheric "striæ," with the best methods of observation and measurement, are most completely dealt with in the papers by Karl Exner in the *Sitzungsberichte* of the Vienna Academy of Sciences and elsewhere. Prof. Pernter accepts what he designates the Montigny-Exner theory as giving a complete and exact explanation of the whole phenomenon.

The theory of halos, of parhelia and anthelia, and allied phenomena given in the third section of the book is founded on the classical work of Bravais "Sur les Halos," which dates from the middle of last century. Though Prof. Pernter speaks of this theory, elaborated by Galle and Bravais, as giving an entirely satisfactory and in all main essentials complete explanation of the phenomena, he is yet able, with the greater mass of more exact records of observations at his command, and the more accurate knowledge as to the form and optical characteristics of ice-crystals—six plates of reproductions of photographs of various types of ice-crystals are given—to confirm or correct in many details the earlier theory. The rarity of some of the appearances necessarily renders numerical confirmation difficult, and it may be well to note, for example, the desirability of further careful observations of the "schiefe Bögen von Löwitz," the lateral arcs tangential to the halo of 22°; and of the parhelia related to the halo of 46°, especially the colour effects when the sun is in the horizon. The whole discussion is fully and clearly given, and is very suggestive of the possibilities of further meteorological research.

The author next deals with the phenomena due to diffraction effects, whether seen directly by transmitted light or by reflection—coronæ, the "Glory" or "Brockengespenst," iridescence of the clouds, &c.—with an exposition of the theory as developed by Fraunhofer, Verdet, and Exner, and based on Airy's development of an expression for the variation in light intensity in the diffraction image. The volume concludes with a complete discussion of the rainbow. Prof. Pernter follows the theory of Descartes to the point where its neglect of the consequences of diffraction leaves it inadequate to explain the phenomena, basing his subsequent development on the Airy "rainbow-integral" for the intensity of light in the neighbourhood of a caustic.

Prof. Pernter suggests that, in a subject of which so much has been written in monograph, his work must necessarily be of the nature of a compilation. He expresses the hope, however, that it may perhaps claim to be more than a mere compilation. No one who has read his work with any attention will be likely to question this claim. Rather it may be taken as the model of what a standard treatise on a branch of physical science should be, written by one whose researches have done very much to remove difficulties and to lighten obscurities. Dealing as it does with matters of absorbing interest, it is unquestionably a book to be read by everyone who takes an interest in the study of natural phenomena.

THE NEW EVOLUTION.

Recent Progress in the Study of Variation, Heredity and Evolution. By R. H. Lock. Pp. xv+299. (London: John Murray, 1906.) Price 7s. 6d. net.

THE labours of a new school of biologists, ably represented in this country by a band of energetic workers at Cambridge of whom the author of the present book is not the least distinguished, have been of great service both direct and indirect to the study of evolutionary method. It was perhaps to be expected that in the first flush of enthusiasm caused by the re-discovery of an important generalisation like Mendel's, judgments should be formed and statements made some of which may seem to pass the bounds of scientific caution; but signs are not wanting that a more restrained attitude is beginning to prevail, and it is a healthy symptom that the free use of the experimental method, rather than mere academic discussion, characterises the work of the new evolutionists.

A noteworthy point in the biological movement of the day is the response that is being given in various quarters to the reasonable demand for quantitative treatment of the facts of variation, selection and heredity. From the side both of the biometricians and of the Mendelians, statistical evidence is being accumulated and dealt with on a scale that might have satisfied Stanley Jevons himself. It must be confessed that the pretensions of these two schools are at present more or less antagonistic to each other and to the convictions of orthodox Darwinians; it is certain, however, that the questions raised in the course of this three-cornered rivalry are of the greatest importance, and that nothing but good can come of their thorough discussion.

The book before us gives an elementary but generally clear and skilful exposition of the present aspects of the evolutionary problem. It is the work of one whose sympathies are confessedly Mendelian and mutationist, but who shows a real desire to do justice to the views of opponents. Mr. Lock's point of view is far removed from that of certain half-

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